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Stratification of Forest Land for Timber Management Planning on the Western National Forests

J. H. Wikstrom and S. Blair Hutchison

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USDA Forest Service Research Paper INT-108, 1971
INTERMOUNTAIN FOREST AND RANGE
EXPERIMENT STATION
Ogden, Utah 84401

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

INT Ogden

REPLY TO: 4820 Production Economics October 29, 1971

SUBJECT: Forest Land Stratification Study

TO: Chief

Enclosed is a report of the study, Forest Land Stratification for Timber Management Planning on the National Forests of the West, that you requested the Intermountain Station and six Western Forest Service Regions to undertake cooperatively. Although we have no basis for saying the data presented in this report represent a statistical average for the western National Forests, they do indicate the general nature of the situation.

This study concludes work initiated in response to Recommendation No. 4 of the 1966 General Integrating Inspection of the Northern Region and the Intermountain Station. We have had the full cooperation of the Regional Forester and staff of each of the six Western Regions in carrying out this study. It is, therefore, with great satisfaction that I submit this report to you on behalf of the Station and the cooperating Regions.

Robert W. Harris

ROBERT W. HARRIS
Director

Enclosure

COVER PHOTO: A 17-year-old stand of lodgepole pine on the Gallatin National Forest, Montana. The stand was thinned in 1962.

GORDON FISCH

USDA Forest Service
Research Paper INT-108
October 1971

Stratification of Forest Land for Timber Management Planning on the Western National Forests

J. H. Wikstrom and S. Blair Hutchison

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
Forest Service
U. S. Department of Agriculture
Ogden, Utah 84401
Robert W. Harris, Director

ABSTRACT

The area of forest land now considered suitable and available for sustained timber management on six western National Forests is about one-fifth less than previously reported. The reduced area is not greatly different from the area used as a basis for allowable cut calculations.

The reduction in area estimates reflects more precise consideration of land productivity, land instability, isolation of small stringers and patches of forest land, and impacts of improved multiple use planning. Revised classifications of forest land in terms of planned use contributed most to the reduction of areas classed as commercial forest land. This in turn largely reflects an improved data base and procedures for multiple use planning.

Adequate information is not available to determine how much the reduction of the timber growing base area will reduce the allowable cut of timber on the six Forests studied. However, the impact on allowable cut will be less than the reduction in area. On many Forests, adjustments have been made for various constraints on timber harvesting and allowable cut estimates have been calculated for only the more accessible and productive forest areas.

This study emphasizes the need for resource inventory work that will describe and update timber and other resources in relation to the land, land-use status, and other factors that affect forest development and use. Timber and other resource inventories must be coordinated and related to land characteristics and other current factors that are significant in the multiple use management of these public forest lands.

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Introduction

Between 1952 and 1969, total timber harvested in the West showed an increase of 35 percent. In this same period, timber cutting on the National Forests of the West showed a dramatic 154 percent increase, from 3,855 million board feet to 9,798 million. From a significant, but somewhat secondary place in the Western timber supply picture, the National Forests have moved to a dominant role.

As long as the level of timber harvested on National Forests was relatively low, the question of how much wood the Forests could produce within a program of sustained yield was neither immediate nor critical. However, as the rate of cutting has increased, the question of upper limits of cut has become a current issue — often a crucial one. This question has become especially critical on those National Forests where increasing the annual cut means harvesting timber in more difficult areas of terrain, the capabilities of which are yet to be adequately determined. These areas tend to be physically and biologically more complex and much more information about them is required to plan acceptable usage of them.

Even under the best circumstances this question of proper cutting levels would be hard to answer; and it has now been greatly aggravated by the increase of other demands on the Forest. Today, more watershed protection is required, recreation use is mounting, and there is greater interest than ever before in maintaining scenic quality, fish and wildlife habitat, and other values. It is apparent that all of these other requirements of management are going to have a greater impact on timber yields — at least in the next few decades — than had formerly been anticipated.

In recent months the allowable cut estimates on some National Forests have been reduced because of second thoughts about the size of the harvest that could be sustained. On other National Forests there has been public clamor to reduce cutting levels which are alleged to be too high for sustained yield. There are counterclaims, of course, that National Forest harvest levels are quite reasonable. Certainly on many Forests if more intensive management were applied, the cut could be substantially increased in time.

Throughout this report we have used the term "timber growing base" when referring to forest land suitable and available for timber growing. To many this term "timber growing base" is synonymous with "commercial forest land" and even the standard Forest Survey definition of "commercial forest land" is forest land suitable and available for timber growing. However, in some circles "commercial forest land" includes any forest land from which timber may be cut. Therefore, since this study is concerned with identification of only the forest land suitable and available for timber growing, the term "timber growing base" is used to avoid confusion.

Since allowable cut levels and management plans are functions of the assumptions underlying them, the principal effort of this study has been directed to reexamining the stated and implicit assumptions with regard to forest land stratification on the National Forests. The procedures for implementing the assumptions have also been examined.

The most recent timber growing statistics for the West (excluding Alaska and Hawaii) reveal that there are 109 million acres of forest

land in National Forests. Of this total, 71 million acres have been classed as "commercial;" that is, *the timber growing base.*

In this report we will answer the following questions:

- HAS THE TIMBER GROWING BASE BEEN PROPERLY DETERMINED? IN OTHER WORDS, HAVE ALL THE FACTORS AFFECTING THE SUITABILITY AND AVAILABILITY OF THE FOREST FOR TIMBER GROWING BEEN ADEQUATELY TAKEN INTO ACCOUNT?
- HAS THE TIMBER GROWING BASE BEEN SUBDIVIDED IN A MEANINGFUL WAY THAT REFLECTS TIMBER GROWING OPPORTUNITIES AND PROBLEMS?
- HOW CAN THE CLASSIFICATION OF FOREST LAND FOR TIMBER PRODUCTION PLANNING BE IMPROVED?

This study has been directed by the Intermountain Forest and Range Experiment Station. However, it has been a cooperative endeavor, involving National Forest and Regional Office personnel in the six Forest Service Regions headquartered at: Missoula, Montana; Denver, Colorado; Albuquerque, New Mexico; Ogden, Utah; San Francisco, California; and Portland, Oregon. Much of the work in connection with this study was done by National Forest Systems people and much of their thinking has gone into the study. The conclusions drawn in this report, however, are solely the responsibility of the Intermountain Forest and Range Experiment Station.

A word of caution! Only six National Forests, or portions thereof, were analyzed to derive study data and other information presented here.

Lolo National Forest (portion),
Arapaho National Forest,
Coconino National Forest,
Boise National Forest (portion),
Klamath National Forest — East Working Circle,
Gifford Pinchot National Forest — Gifford Pinchot Working Circle.

Selection of the six Forests was based primarily on convenience, but they presumably represent the range of variation in land and land use factors. However, collectively they may or may not represent the average situation in the West; we simply don't know. Moreover, the fact that we identify and discuss categories in this study beyond those intended in the original survey reduces the reliability of the data. They are useful only in describing the problem of forest stratification and indicating the general magnitude of the factors considered.

To recapitulate, the specific purpose of this study is to take a first step toward clarifying the issue of identifying and stratifying the timber growing base. This is an exploratory study to determine if past estimates of the timber growing base (commercial forest area) in the western National Forests are reasonably accurate. The findings on the following pages are based partly on an evaluation of physically measurable factors and partly on an appraisal of the inventory system in relation to the purposes for which the timber data are to be used.

Procedure for determining the timber base

Forest land is usually quite easily distinguished from nonforest land on aerial photographs. The usual procedure in making timber inventories is to begin with the total forested area and then identify those areas not suitable or available for timber use, using physiographic, soil, hydrologic, ecologic, and land-use information. After the forest land suitable and available for timber growing has been identified, this area must be stratified in a way that reflects degree of suitability and availability for timber production, types or kinds of management needed, and product output options.

There are some areas that are either not suitable or not available for inclusion in present timber growing plans. These areas can be divided into six general classes:[1]

(1) Forest land formally set aside for wilderness, primitive areas, etc.
(2) Forest land that does not meet minimum productivity or wood quality standards.
(3) Forest land that is too unstable or too steep to be logged without damage to environment.
(4) Forest land that occurs in small isolated patches that are not practical to utilize and which often have higher value for other purposes.
(5) Forest land administratively withdrawn from timber use in multiple use plans.
(6) Forest land being considered for wilderness or other uses that would preclude timber utilization, but for which a decision has not been made.

The underlying problem in past inventories has been the inadequacy of information about the land, its ecology, and land use. This study was conducted, therefore, only after consulting National Forest staff specialists who developed more complete information on geomorphology, ecology, and land use. This information then provided the basis for timber inventory classification. Details are discussed later in this report.

[1] *It is important to recognize the currentness of the timber growing base classification. There is nothing permanent about the decisions in forest land classification. For example, areas presently regarded as usable for timber growing may not be so regarded a decade from now, as better information about the land becomes available or because of changed land use decisions. Likewise, areas now considered unsuitable or unavailable for timber growing may later be regarded as usable.*

Overestimation of the timber growing base

Former timber inventories on the six National Forests that were analyzed indicated an aggregate timber growing base area of 4.1 million acres. However, this timber growing base is reduced to 3.2 million acres when careful account is taken of soil-slope conditions, land productivity, and land use. In other words, the area suitable and available for growing tree crops on these six National Forests is 22 percent less than had been previously estimated.

The timber growing base was not overestimated to the same degree on all of the six Forests. On the Gifford Pinchot Working Circle, the decrease is only 11 percent as compared to 40 percent decrease on the Arapaho National Forest. (Data for each cf the six areas are presented elsewhere in this report.) The significant point is that, in every case, a more careful and critical look at availability, growth capacity, and land suitability (primarily stability) resulted in a significant reduction of the area deemed suitable and available for timber growing.

These reduction figures did not come as a surprise; National Forest administrators have recognized this problem for several years and have been decreasing the area figures used in calculating allowable cuts. This study is, therefore, distinguished primarily by the fact that it represents the most systematic effort to identify and measure the factors that reduce the land base for timber growing on the National Forests.

Much of the land excluded from the timber growing base by the tighter standards and more systematic classification of this study is on the lower end of the productivity scale. Thus, the 22 percent reduction in timber growing base area on the six Forests does not indicate that the timber producing capability will be reduced by that amount. Data inadequacies prevented determining the exact effect of area reductions on yield capabilities for all of the National Forests. However, on the Coconino National Forest the timber growing base area was reduced by 28 percent, but the growth capability of that National Forest was reduced only 18 percent. On the Gifford Pinchot Working Circle the decline in growth capability was 7 percent as compared with 11 percent decrease in acreage.

The factors that affect classification of the timber growing base vary so widely from place to place that few generalizations are safe. Land use considerations of one sort or another were a big item on all but one National Forest. However, land instability, low productivity, and uneconomic units are all important to different degrees on different Forests.

Following are the percentages of the total 0.9 million acres eliminated from the timber growing base of all six National Forests. Please remember that we have no basis for saying just how representative is each of these percentages. They are presented only to indicate that each factor is important.

	Percent
(1) Areas not capable of producing 20 cubic feet of wood per acre per year	20
(2) Land too unstable to be logged without serious damage and other unsuitable forest soil	19
(3) Patches of timber land too small and/or too isolated to be utilized for timber production	7
(4) Commercial quality lands administratively withdrawn from timber use in multiple use plans	35
(5) Areas under study to determine appropriate land use such as wilderness for which a final decision has not yet been made[2]	19
	100

[2] *Plans for the areas in category (5) are obviously incomplete pending a decision which will either put them in or out of the timber growing base.*

Variations within the timber growing base

On the 3.2 million acres *that comprise the timber growing base* in the six Forests there is a wide range of productivity, but there are also other differences. Some stands are less economical to develop than others due to location and type of timber. In fact, high development costs or low product values may in some cases preclude utilization in the foreseeable future. Some potentially utilizable areas can't be safely logged until systems that cope with fragile soil problems are developed. Some stands present very difficult silvicultural problems. In other cases nontimber uses and values will preclude capturing the full yield potential of the land.

Most National Forests have made some attempt to adjust their planning to these variations. The Timber Management Division of the Forest Service, Washington Office, prepared a tentative classification scheme for nationwide use in defining subcategories of the timber growing base in 1967. The important point is that on the six Forests studied a significant part of the total 3.2 million-acre timber growing base (as indicated below) is either economically or technologically unavailable at present although in the future it presumably will be usable.

	Percent
Currently usable, both economically and technologically	87
Unavailable, either economically or technologically	13
	100

Economic feasibility is almost certain to improve with time, but the technologically unavailable timber represents a more serious problem. Some of the timber in this currently unavailable 13 percent is growing on steep slopes that are unstable and should not be logged using conventional systems, but timber in this category may be obtainable in the future under the new system of logging (fig. 1). Development of economic long-reach yarding systems such as the skyline and balloon systems that require substantially fewer roads will eventually be necessary to avoid reduction of cutting levels. On a National Forest like the Boise, which has much unstable land, there is not much time remaining for achievement of such development.

Figure 1.—Aerial view showing roads built for logging on an area in northern Idaho. At present, logging technology is heavily dependent on roads. In steep country it is not uncommon to build 12 or more miles of roads per square mile of forest land harvested. The steeper, less stable slopes simply cannot stand such disturbance. The utilization of most of these areas, therefore, will depend on aerial logging systems requiring fewer roads. Some of the most unstable slopes should not be logged at all and therefore should not be part of the timber growing base.

Sources of the problem and development of more useful and realistic area data

Why has too much land been included in the timber growing base in most, if not all, western National Forests? Primarily it is because information required for a complete job of stratifying forest land has been almost totally inadequate; not enough has been known about the productivity, stability, and ecology of the land. Furthermore, land use intentions have not been as completely or specifically spelled out as they should be, and this affects inventory classification.

A longstanding problem that is only now being corrected is the deficiency of information about soil-slope characteristics and the performance of water flows on and through the soil in these various situations. Without these facts, the areas that are either too unstable to tolerate logging or require special logging methods cannot be identified and delineated.

The principal factor undermining timber inventory data has been the incompleteness of past multiple use plans. The areas to receive special management that would reduce or eliminate timber yield possibilities have not all been identified and mapped. Even where adequate mapping has been done, the constraints and broad guidelines have not in some cases been spelled out clearly enough to provide a basis for timber classification.

Each of the six Western Regions is moving rapidly in the direction of making its multiple use plans more definitive and articulate. However, before the National Forests can completely accomplish this they must have the necessary land information, ecological data, information on use demands, and a clear sense of purpose before preparing or revising multiple use plans. Only after really meaningful multiple use plans are prepared will it be possible to accurately classify land for timber management planning.

Timber area-and-volume estimates in most cases have been based on the classification and measurement of sample points and sample acres without giving particular attention to the suitability and availability of the Forest on which these samples are taken or the size of the stands represented by the samples. This has tended to adversely affect the realism of the inventory data.

More realistic stratification of the timber growing base is needed

The recent acceleration of timber cutting and management on the National Forests has created demands for timber data that describe problems, opportunities, and management needs in a meaningful way. One of the most serious weaknesses of past data was the inadequate portrayal of the varying degrees of suitability and availability of commercial forest land for timber use. Before the costs of different levels of production can be determined, it will be necessary to classify the timber growing base to reflect the degree of suitability and availability for timber growing. Each of the six Regions and the Washington Office Division of Timber Management has struggled with this problem, but there is still no overall categorization that includes all the significant factors that affect the cost of using forest land for timber production and the results expected.

Figure 2 outlines the basic classification for the timber production planning that now appears to be necessary on National Forest land. Total forest area should be subdivided into three broad classes that can in turn be subdivided as necessary.

1. *Nonproductive, nonsuitable, and withdrawn areas.* Usually this class is called "noncommercial" and would include:

   - All forest areas that lack the capacity to grow at least 20 cubic feet of timber per acre per year — 20 cubic feet being the established dividing line between "productive" and "nonproductive."
   - Productive areas that have been withdrawn from timber use in wilderness areas, primitive areas, etc.
   - Productive areas that have been withdrawn from timber use in multiple use plans.
   - Productive areas that are so steep, unstable, or rocky that they cannot be used for timber production without serious damage to land or water or other intolerable complications.

2. *Decision deferred*

   Areas for which a final decision has

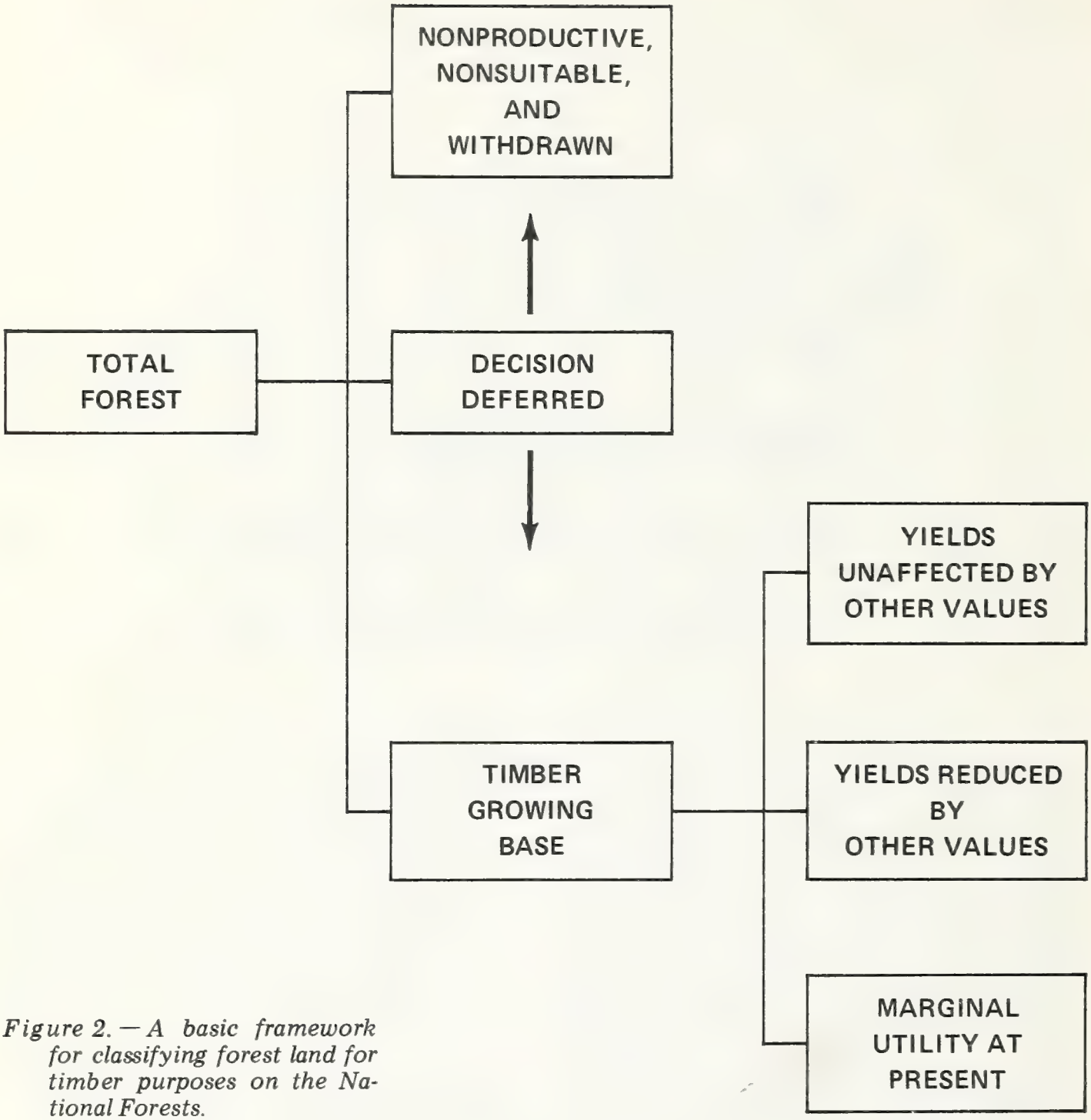

Figure 2. — A basic framework for classifying forest land for timber purposes on the National Forests.

not been made as to management purpose and on which roadbuilding, logging, and other activities associated with timber use would reduce the options for later choice. Included in this category would be areas under consideration for wilderness and any other uses with which timber cutting and timber growing would be in conflict.

3. *Timber growing base*

Productive areas that are suitable for timber use that have not been temporarily or permanently withdrawn from such use. In addition to describing such areas as to forest type, timber size, and productivity, three other broad subdivisions are needed. These follow:

(a) *Yields unaffected by other values*

Areas suitable and available for timber growing that presently can be used for this purpose without a significant reduction of timber yields.

(b) *Yields reduced by other values*

Areas presently suitable and available for timber production on which protecting or enhancing of other values such as recreation, esthetics, and watershed protection will result in reduced timber yields.

(c) *Marginal utility at present*

To avoid the possibility of overcutting, certain areas of the timber growing base are not included in the calculation of current cutting budgets because the current utility of these areas is shadowed by limitations or restrictions. These "marginal" areas include the following:

- Areas where there is low probability of the timber being utilized in the immediate future because of excessive development costs or low timber-product values.
- Unstable land areas that cannot be logged using present methods without damaging the environment but which may be utilized for timber once a logging system is developed that will not damage the environment.
- Merchantable stands on sites where reforestation following logging would be extremely difficult or expensive because of adverse site and/or habitat conditions.
- Extensive unstocked areas for which money for planting or seeding is not likely to be available in the near future.
- Extensive areas of stagnated timber below utilizable size and areas that will become stagnated or deteriorated to the point of not producing utilizable wood unless and until necessary cultural work is done but for which the financing is not likely to be available in the immediate future.

General observations

Two general observations can be made as the result of this analysis of forest land stratification on the National Forests.

(1) Before timber inventory data can be organized to provide clearcut and accurate guidelines for management, the plans for land use must be carefully developed. Definitive multiple use plans require a broad base of knowledge about land stability, watershed characteristics, ecology, and resources. In other words, timber inventories and plans are not and cannot be independent entities but are subordinate aspects of a total multiple use planning process. Anything less than complete and definitive multiple use plans results in timber being cut where it shouldn't be cut and roads being built where they shouldn't be built on the one hand, and misguided reservations of timber on the other.

(2) Some top quality timber lands may not be used for timber production because they have other more important values. However, on lands classified as not suitable for timber growing (or otherwise withdrawn from such use) the production of timber is generally lower than on lands that remain part of the timber growing base. Thus, although tightening of timber production standards reduces the actual area of productive forest land, it will not proportionally reduce the timber production capabilities. In fact, any increase in management expenditures will likely buy greater increases in future timber output if concentrated on the smaller area of better quality land.

Results

The areas of the timber growing bases of the six National Forests as estimated in the previous inventory and as revised in this study are compared in table 1. This reveals very clearly how misleading such information can be if land suitability for timber use, land capability, and land availability are not adequately considered. It is well to remember, though, that land use intentions change and they have changed in recent years. For that reason, the earlier data reflects in some cases outdated thinking relative to use expectations.

The specific reasons for the decline in the timber base on each National Forest are shown in table 2. As mentioned earlier, factors that cause reduction of the timber growing base differ from place to place. However, one consistent result of careful reexamination was the elimination of areas from timber production plans because other uses and values are more important than timber yields and timber production. In many cases this conflict is based less on the actual cutting than it is on the roads made necessary by the cutting.

LOW PRODUCTIVITY

If forest land is to be considered part of the timber growing base, it must be capable of growing at least 20 cubic feet per acre per year; this is a longstanding Forest Service standard. One may properly ask whether this is the best standard for all places. It probably isn't, but we have not tried to solve that problem in this study. Rather our attention has been directed to the question of how well this existing standard has been applied (fig. 3).

Table 1. — Comparison of timber growing base areas by study unit, previous inventory, and 1969 inventory

Study unit	Previous inventory		1969 study inventory	Difference	
	Year	*Thousand acres*			*Percent*
Lolo area,[1] R-1	1966	745.2	629.1	116.1	-16
Arapaho N.F., R-2	1958	668.4	399.6	268.8	-40
Coconino N.F., R-3	1961	[2] 793.5	568.6	224.9	-28
Boise Area,[1] R-4	1964	385.3	273.3	112.0	-29
E. Klamath W.C., R-5	1968	420.1	372.3	47.8	-11
Gifford Pinchot N.F., R-6	1960	[3] 1,041.2	921.6	119.6	-11
Total		4,053.7	3,164.5	889.2	-22

[1] *Portion of National Forest.*
[2] *731.8 thousand acres classed as operable; 61.7 thousand acres classed as nonoperable.*
[3] *Area adjusted to correct for adjustment made in total area estimate for the Working Circle.*

Table 2. — Differences in estimates of timber growing base area, in thousand acres, between study inventory and previous forest inventory by unit and cause

Study unit	Total difference	Differences due to: Low productivity	Unstable and unusable land[1]	Isolated patches and stringers	Land use conflicts[2]	Deferred	Land exchange sampling error
	Thousand acres						
Lolo Area,[3] R-1	116.1	--	23.4	--	32.7	58.9	+1.1
Arapaho N.F., R-2	268.8	67.2	2.2	9.9	127.5	64.9	-2.9
Coconino N.F., R-3	224.9	57.3	[4]108.3	[5].3	36.8	22.2	--
Boise Area,[3] R-4	112.0	23.5	25.6	11.2	43.3	5.6	+2.8
E. Klamath W.C., R-5	47.8	7.9	--	37.9	2.3	--	-.3
Gifford Pinchot N.F., R-6	119.6	17.2	10.1	--	68.3	19.3	+4.7
Total	889.2	173.1	169.6	59.3	310.9	170.9	5.4

[1] *Includes rock talus, rock land, and other unusable Forest soils.*
[2] *Crest and special multiple use zones are included in this category.*
[3] *Portion of National Forest.*
[4] *Over 100,000 acres are stable but unusable for timber production because of other soil factors.*
[5] *Most isolated patches and stringers on this unit were on unusable Forest soils.*

We found that the standard has not been applied uniformly or accurately. The usual procedure has been to determine soil productivity (site quality) from age-height relationships of dominant trees. Growth capability has then been determined from yield tables or yield equations based on the yield tables. Inherent in the procedure is the assumption that the area being evaluated can support as many trees as the land on which the yield table data were collected. This is not always true and generally is not true in stands located on the more arid fringe of the forest. In areas of low rainfall each tree requires more room than is "normal" to fulfill its moisture requirements. Thus, "full stocking" in such instances may be considerably below yield table levels. In any locality, rock outcrops, shallow soil, or soil variations may preclude stocking at yield table levels (fig. 4).

All inventory samples were examined carefully in areas where it appeared that stocking constraints might exist. This required consideration of certain ecological subtleties. For example, in some localities, the presence of a juniper tree (a noncommercial species) would not necessarily indicate that a commercial species such as ponderosa pine could grow there. Yield table estimates of growth were discounted in proportion to the stocking capability.[3] For example, if the information available indicated that only 50 percent stockability was obtainable, then the yield estimate derived from the site tree measurements and yield equations was reduced 50 percent. Field samples were classified as unproductive forest land and excluded from the timber growing base if they failed to meet the 20-cubic-foot standard which included consideration of both site and stocking capability.

Table 2 shows that many stands formerly considered to be part of the timber growing base don't measure up to the standard when

[3] *For the lack of a better basis, it was generally assumed that the existing tree stocking on marginal areas (or the stocking formerly present if the area had been disturbed) is the maximum the land could support.*

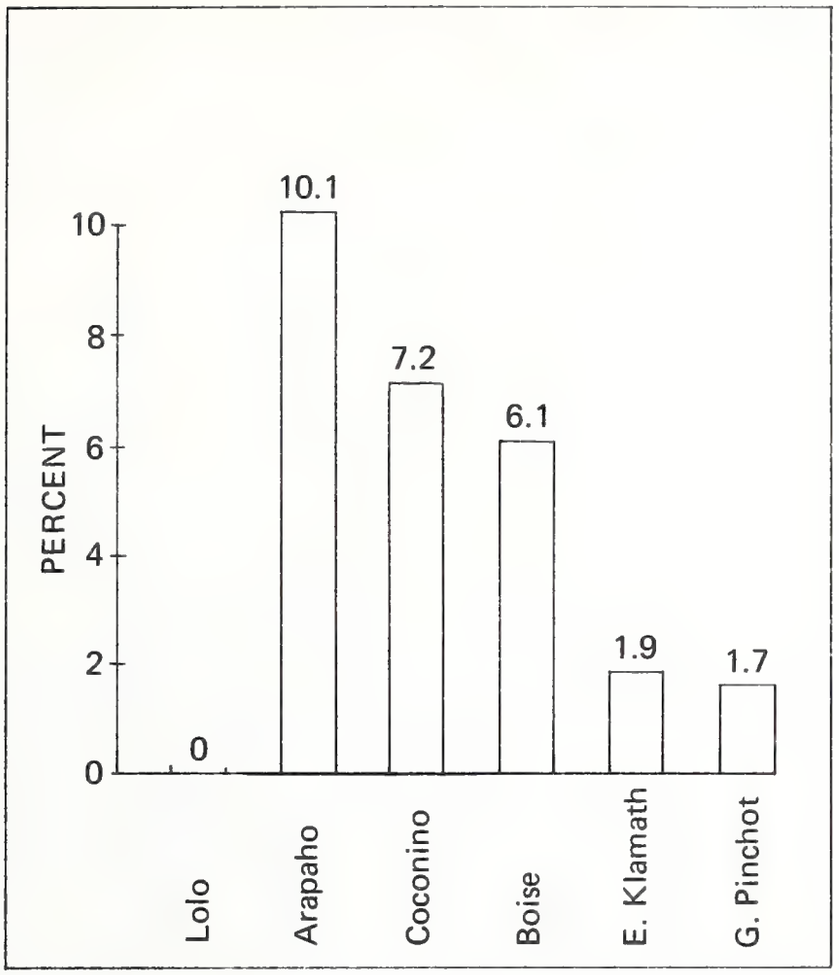

Figure 3. — Reductions in the timber base because of low productivity.

stockability is taken into account. As would be expected, the submarginal forest is most common in the central and southern Rockies.

LAND INSTABILITY

Each cooperating Region either made or had already completed a detailed or extensive soil survey for the National Forest included in this study (fig. 5). As part of the study, Forest Service soils-and-hydrology specialists then classified the forest land according to suitability for timber use, taking account of the basic structural stability of the slope, susceptibility of the soil surface to erosion, and the capacity of the land to receive, store, and discharge water. From such information they delineated the following classes of forest land on maps:

(1) Stable forest land usable for timber production with present timber growing and harvesting technology.

(2) Unstable forest land potentially usable for timber if there are improvements in timber growing and harvesting technology requiring fewer roads and less on-the-ground skidding of logs.

(3) Unstable forest land completely unusable for timber production because it is extremely susceptible to mass land slumps, flows, and slides or because the soil surface would wash away too readily if the vegetation were seriously disturbed. Snow avalanche or potential avalanche areas, rock talus, and other forms of rock land are also included in this category though the land itself is not unstable. On the portion of the Lolo National Forest studied, for example, much of the land in the "unstable" category is rock land and rock talus. On the Arapaho, mass land move-

Figure 4. — Ponderosa pine growing on a very poor site, Ashley National Forest in Utah. Timber could be harvested from areas such as this one, but the establishment of a new stand would be difficult and costly. Small wood values and big problems should rule such land out of the timber growing base.

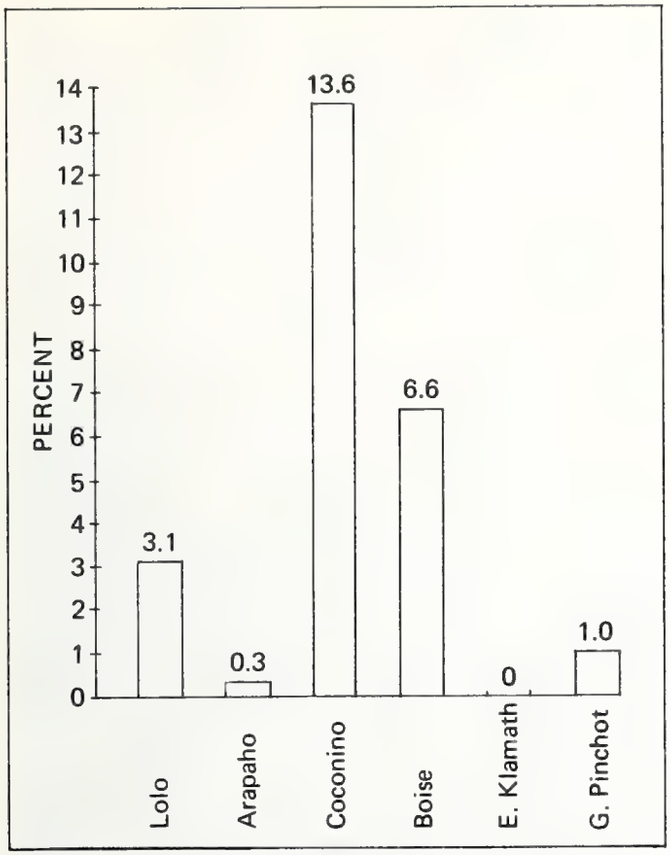

Figure 5. — Reductions in the timber base because of land instability. (Amounts shown for Lolo and Coconino include other soil factors, see table 2.)

ment is the principal problem, but it is not extensive. On the Boise, the unstable category is made up primarily of granitic soils highly susceptible to both surface erosion and mass slumps.

Land instability is a localized problem. On some National Forests it is not an important factor. In others, like the Boise, it is the most crucial single consideration in land classification.

SMALL ISOLATED PATCHES

Throughout the Western United States, forest land capable of producing timber crops commercially is located within a broad or narrow elevational range that varies by latitude and rainfall patterns. At lower extremes it generally fades into noncommercial timber, brush, and grass. At the upper elevations, subalpine timber and shrubs take over. In both the lower and upper transition zones those trees that are of commercial quality often occur in small scattered patches where, for one reason or another, there is greater moisture or deeper soil (fig. 6).

In most of the previous timber inventories, forest land area was estimated from point samples on aerial photographs. Even very isolated patches of timber land as small as 1 acre in size were considered to be timber growing land if they met the other requirements. Experience has shown this to be a faulty procedure because on many such areas the costs of, and damages from, utilization are more than the trees are worth.

In our analysis, no area smaller than 10 acres was considered usable for timber growing. Areas of productive forest land from 10 to 40 acres were considered usable only where they were close to larger bodies of forest land and could be utilized along with the main forest or were otherwise highly accessible. In all cases, the criteria of size and accessibility for these 10 to 40 acre areas were developed locally by National Forest and Regional personnel (fig. 7).

Table 2 indicates that the small isolated patches of timber excluded on two Forests (Lolo and Gifford Pinchot) did not account for much acreage. On the East Klamath Working Circle and on the Boise National Forest, however, large acreages were excluded due to size

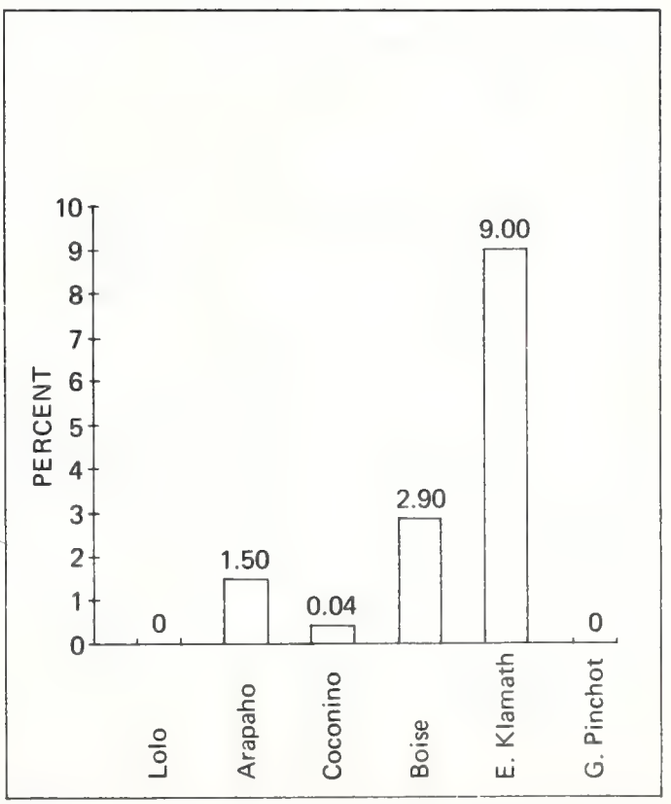

Figure 6. — Reductions in the timber base because of isolated stringers or small patches.

Figure 7. — Small scattered patches of Douglas-fir on the Challis National Forest in Idaho. It is highly questionable whether the timber is worth the effort of getting it out. Also, roads and skid trails that would be created by logging would produce lasting scars that can hardly be justified by timber values. Many such stands provide extremely important wildlife cover.

WIKSTROM J. H. and S. BLAIR HUTCHISON

1971. Stratification of forest land for timber management planning on the western National Forests, USDA Forest Serv. Res. Pap. INT-108, 38 p., illus.

The area of forest land suitable and available for timber production on National Forests of the West has been overestimated, probably as much as 22 percent. Forest land misclassified for timber use includes (1) highly unstable land, (2) land low in timber productivity, (3) forest land devoted to nontimber use, and (4) patches and stringers of forest land too small and/or too isolated to be used in timber production.

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and isolation. The impact of these exclusions on timber yields is likely to be relatively light in most cases because the yield capability of the small forest patches tends to be low. Also, shallow soils and/or limited precipitation tend to make regeneration of new stands slow and difficult. In fact, severe disturbance of many such stands will cause them to revert to some nonforest cover type.

LAND USE CONFLICTS

When considering the effects of land use plans on timber availability, two points should be kept in mind:

First, land use situations vary greatly from National Forest to National Forest and also within the individual Forests. The situation in one travel influence zone, for example, may permit extensive timber cutting and in another little or no cutting.

Second, land use requirements are always changing and never will be static. There have been many changes in the demands upon these Forests since the previous timber inventory (fig. 8). Consequently, the differences shown in table 2 reflect both changes in forest land use and the results of a more critical look at forest land use.

The area *excluded* from the timber growing base for land use reasons includes only those areas on which no logging is planned beyond the salvaging of dead, dying, and hazardous trees. On other areas in the timber growing base,[4] timber utilization will be less than complete due to priority of other values such as recreation, esthetics, etc.

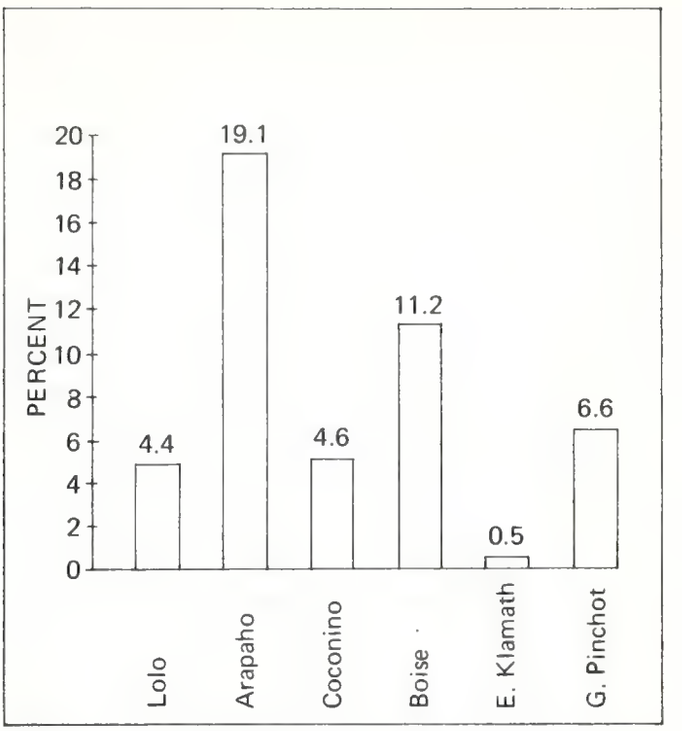

Figure 8. — Reductions in the timber base because of land use conflicts.

[4] *In the past there has been some confusion about how to define commerical forest land (the timber growing base). Actually, it is not related* per se *to cutting. In other words, timber has been and will be logged from noncommercial areas. Commercial forest is land that is being or will be used in the growing of timber crops for industrial use where management inputs are made for this purpose.*

Effect of criteria used on productive capacity

The timber harvest that can be sustained from any forest area depends upon three factors:

- The amount of forest area that is suitable and available for timber production
- The productive capacity of this land
- The intensity of timber management

In the short run, of course, the cutting level also depends upon the amount of merchantable volume immediately available.

Comparison of timber volume estimates of an earlier and a current inventory is for the most part risky because of the impact of cutting in the interim period. Also, during the interim between the two inventories for any unit, improvements have been introduced in volume estimating techniques. Two separate compilations were made for the Coconino Forest using the 1969 data; this enabled us to avoid the above problems and more realistically compare impact of the factors studied on the timber base area with impact on volume and growth capacity. The first estimate of timber base area, volume, and growth was based on the subjective field classification of inventory volume samples; this is the way inventory classification has been handled in the past. The second compilation was made by using study criteria.

It is significant that the reductions in the timber volume were about the same as the reduction in growing base area, but the impact on growth capacity was much less. The following tabulation shows these reductions:

	Percent
Timber growing base area	28
Timber volume	29
Growth capacity	18

The fact that there was a greater reduction in volume than in growth capacity suggests there has been proportionately more logging on the more productive land. Further analysis of growth capacity leads to the conclusion that following logging the better sites have regenerated more rapidly.

The real effect is less. — The 22 percent reduction in the estimate of timber growing base for the six National Forests does not represent an actual 22 percent loss of area and productivity for timber growing. It is true that the awakening interest in forest values other than

timber has placed additional constraints on timber growing opportunities. However, the large reductions reported here are mainly reductions in estimates rather than reductions in fact. For example, thousands of acres of very steep and unstable lands and areas not capable of producing 20 cubic feet of wood annually should never have been called suitable and available for timber growing in the first place. The reduced estimates of timber growing base suggested by the findings of this study, therefore, are not so much because of recent encroachments of other uses on the timber growing base as they are a matter of more realistic estimation of this base.

In recent years there has been growing recognition that important factors affecting suitability and availability of forest land for timber use have been overlooked in timber inventory planning. In many cases, managers of National Forests have made judgment adjustments of timber inventory estimates to correct for factors not considered in timber inventories. As indicated in table 3, although the estimate of the timber growing base for the six National Forests studied was 4.1 million acres, the cutting levels established following completion of the inventories for these Forests were based on 3.5 million acres being used for timber production. In some cases, subsequent reevaluations have resulted in further changes in the timber growing base for purposes of calculating the allowable cut.

Table 3. — Area of the timber growing base: from previous inventory; area used in management planning from previous inventory; and, area from study inventory by unit

Study unit	Area of timber growing base		
	Previous inventory	Management plan	Study inventory
	Thousand acres		
Lolo, R-1	745.2	745.3	629.1
Arapaho, R-2	668.4	446.0	399.6
Coconino, R-3	793.5	599.9	568.6
Boise, R-4	385.3	368.7	273.3
E. Klamath, R-5	420.1	420.1	372.3
Gifford Pinchot, R-6	1,041.2	960.5	921.6
Total	4,053.7	3,540.5	3,164.5

Recommendations

If any overall criticism of past practice is in order it is that the effort going into the development of coordinated plans for the management of National Forests has been inadequate. The major problem is lack of basic planning information, much of which is costly to obtain.

It could be said in short that the problem is inadequate financing for basic data collection, analysis, and planning. The problem is more than one of financing for timber inventories. The timber resource cannot be described meaningfully unless it can be described within the context of the land, ecology, and land use situation. Thus, there must be balanced financing for soils-hydrologic surveys, ecological habitat surveys, and resource inventories.

The data presented indicate that when there is an absence of adequate information about the land and ecology and there is also inadequate multiple use land management planning, then the tendency is to overestimate the timber growing base area. This in turn results in a temporary inflation of timber cutting levels. *Far more serious, however, is the fact that to include forest land in the timber growing base that will not, or probably will not, be used for the production of industrial wood is to imply the timber growing base is larger than it really is and the need for management effort is to that degree being falsely discounted.*

The six Forest Service Regions have been quick to recognize the implications of the study findings and many of them have already moved rapidly to correct deficiencies in past procedures. In general the effort has been to relate the timber inventory classification to improved multiple use plans. This has required accelerating soils-hydrologic surveys to provide land stability information in advance of timber inventories. In addition, where forest land management activities are influenced by physiography, ecology, accessibility, or use objectives, maps are being prepared to permit classifying the timber inventory data accordingly.

There is a premium on "in-place" information for National Forest planning. Unless mapping is used, it is impossible to relate sample plot information about the timber-to-land capability, land use plans, and other pertinent characteristics that are area related.

The Forest Survey Research Units in the West are now cooperating with National Forest System Timber Inventory staffs in designing timber inventories that relate the timber "in-place" to the land, habitat, and land use situations and provide more "in-place" information on the timber itself. The timber inventories now being designed and planned vary in detail from Region to Region, depending on the individual Region's timber data situation and data handling capabilities. Although changes and improvements are already underway, it is still appropriate to observe that thoroughly meaningful timber inventories require progress along the following lines:

- *Multiple Use Planning Must Be Improved*

  The principal conclusion of the Intermountain Station and the cooperating Regions and Forests is that the taproot of the problem of forest land stratification is in multiple use planning. Functional plans can be no better than the multiple use plans to which they are related. Multiple use plans must reveal the land use situation accurately and completely.

  To be complete, the multiple use plan must give specific details about the nature of the management planned on the land available for timber growing on a modified basis only so that the impact of the modifications on expected yields can be determined (fig. 9).

Figure 9. — Example of good cleanup after logging, keeping roads up out of stream bottoms, and use of a residual strip to protect streambanks and aquatic environment.

- *A Coordinated Approach Is Required To Build an Adequate Data Base for Forest Land Management Planning*

  Timber inventories should not be undertaken without making full use of the information required to relate the timber to the land and land use situation. In other words, there must be closer coordination of timber inventory with soil-hydrologic surveys and studies, ecologic surveys, and multiple use planning.
- *Increased Funding for Surveys and Resource Inventories Is Essential*

  Substantial increases in funding will be required in the future for the collection and development of planning information. The more intensive the management, the more intensive must be the effort to develop planning information. Demand for forest land for all uses has increased in recent years, requiring that the National Forests be managed more intensively. However, work in the area of basic data collection and information development for planning have not kept pace with the need.
- *Research Effort in Forest Management Planning and Inventory Techniques Should Be Increased*

  More data collection will not by itself produce a solution to forest land management problems. Although a significant part of the problem is lack of data, a major difficulty is the need to make more effective use of the data collected for management planning. There is a need, also, to improve data collection techniques both to achieve increased efficiency and to decrease data collection costs.
- *Timber Inventory Planning Must Be Improved*

  The failure of timber resource statistics to serve the information needs of National Forest planning as well as they should is partly the fault of overpreoccupation with certain standard data required for national statistics. The preoccupation with responsibility for standard statistics for Washington Office use has diverted attention from the dynamic and more detailed informational needs of individual National Forests for planning purposes.

  A prerequisite for an adequate inventory of the timber resources of any National Forest, therefore, is a carefully prepared plan that identifies the objectives of the planning effort, lays out the analyses required, specifies the data needed to accomplish these analyses, and describes how the data are to be collected.
- *A MORE DETAILED STRATIFICATION OF FOREST LAND IS NEEDED FOR PLANNING*

  Experience of managers and management planners indicates that a simple "commercial-noncommercial" division of forest land is too general and not adequate to meet National Forest planning needs even at the national level. Neither is it adequate to divide forest land only on the basis of quality or yield-capability classes. Other land characteristics such as steepness of slope, land stability, access, kind of soil, and ecologic or habitat type can have a very significant effect on the cost and opportunity for using the land for timber growing. In addition, the amount and condition of the timber occupying a given area can be a major factor limiting the opportunity for usage. In other words, it is essential to describe the forest land in terms of all the factors that affect its use for timber production and to describe the timber in relation to the land. Furthermore, it is necessary to develop a classification of the timber growing base area that reflects degree of management need and opportunity. It will, however, be impossible to do this without first getting agreement throughout the Forest Service on the planning and analysis models to be used.

APPENDIX

Procedure for timber inventory

Timber inventories generally are based on a double sampling scheme. Initial sampling on aerial photos involves classifying a large number of photo points into broad forest land classes (nonforest, nonproductive forest, and productive forest). For field sampling, the productive forest category is further categorized into a number of strata based on type stand or volume of timber. The field samples provide: (1) information to verify the photo point classification; (2) tree measurement data from which estimates of timber volume can be made; and (3) general information on the condition of the forest.

This double sampling procedure was used on all but the Gifford Pinchot study unit where a single sampling procedure was employed using only field samples. Of the timber inventories used, none were designed to consider all the land and land use attributes evaluated in this study. Information on these attributes was developed afterward and the inventory data recompiled to reflect the influence of land and land use characteristics.

For this study, map data were used and photo points for each study unit were further classified to reflect land use and land characteristics. Basic information was obtained from: timber stand and/or type maps, multiple use land management plan maps, and maps showing soil type and land stability situations. Multiple land use management maps for the study areas were updated to indicate all forest land where management to meet nontimber land use commitments would preclude or restrict timber production. In addition, management intent was specifically described in detail so that impact on timber use and yield could be assessed.

Another map was prepared for the study unit showing undeveloped land for which no access was planned during the next 10 years. Also shown were areas of peculiar ecology or soil situations that could not be used for timber production because of unsolved timber growing problems. In addition, the timber inventory on the study unit was supplemented by the collection of data on stocking capability and description of small isolated patches and stringers of trees.

DOUBLE SAMPLING PROCEDURE

The stratification procedure and results with the double sampling system are illustrated here by using data from the East Klamath Working Circle, Klamath National Forest, located in the Upper Klamath River area of northern California and southern Oregon. This Working Circle, 551,099 acres in size, is dominated by steep slopes, though the soil is relatively stable. The reconnaissance soil survey indicated that most of the forest land is usable now for timber production or potentially usable with some improvements in technology. Some of the area, particularly at higher elevations, is rugged country having productive forest land that occurs in pockets and patches intermixed with nontimber base forest land and barren, rocky areas. At lower elevations the forest cover is broken, with forest areas intermingled with nonforest land. The timber resource on the Working Circle was inventoried for timber in 1968. Utilizing recent aerial

Table 4. — Number of photo points and field samples by land class and photo volume stratum within productive forest land East Working Circle, Klamath National Forest

Land class	Photo sample stratum	Number photo points	Number field samples
Productive forest	1	215	17
	2	818	58
	3	518	32
	4	546	25
	5	606	30
	6	309	13
	7	226	14
	8	39	2
	--	--	--
Subtotal	--	3,277	191
Nonproductive forest	--	692	41
Nonforest	--	342	16
Total	--	4,311	248

photo coverage, 4,311 photo points were classified, giving an area weight per sample point of 127.8355 acres.

$$\frac{551,099}{4,311} = 127.8355$$

The estimate of area by class of land based on the photo samples was as follows:

Land class	Number photo points	Acres
Productive forest land	3,277	418,917
Nonproductive forest land	692	88,462
Nonforest land	342	43,720
Total	4,311	551,099

Every nth photo point sample was drawn as a field sample and visited on the ground. Tree measurements were taken only when the field inspection indicated the sample (1 acre around the photo point) was productive forest land. Also, to improve sampling efficiency, productive forest land photo samples were classified into eight sampling strata prior to field sampling.

Table 4 shows the total number of photo and field samples by class of land and by sample stratum for the Working Circle. As mentioned previously, the field sample information was used to verify the classification of land made from photo point interpretation. The results of the field verification were then used to adjust the photo sample area estimates to correct photo sample misclassification.

Two estimates of area by classes of land were made: (1) The first one was based on the results of the field classification of sample points selected for field sampling as initially carried out by the timber inventory staff (table 5); the second one was based on a classification of field samples using study criteria. The estimates of area by broad land class from the photo point sample were adjusted by using the timber inventory field classification as a base. The results were as follows:

Land class	Acres
Productive forest land	416,617
Nonproductive forest land	101,692
Nonforest land	32,790
Total	551,099

Table 5. — Timber inventory, photo and field classification of field samples by land class, East Working Circle, Klamath National Forest

Land class photo sample	Photo sample stratum	Field classification of land			Total
		Productive forest	Unproductive forest	Nonforest	
		Number of locations			
Productive forest	1	17	--	--	17
	2	53	5	--	58
	3	32	--	--	32
	4	23	2	--	25
	5	28	2	--	30
	6	13	--	--	13
	7	13	1	--	14
	8	2	--	--	2
Subtotal	--	181	10	--	191
Unproductive forest	--	6	35	--	41
Nonforest	--	3	1	12	16
Total	--	190	46	12	248

Using study criteria to classify field samples produced some interesting results. First, 15 of the locations were taken at points on land identified on maps as noncommercial or nonforest. These points were on patches of forest land that were at least an acre in size but not considered suitable for timber growing. Second, when stocking capability was considered, some of the field locations initially classified as productive forest land proved to be in the nonproductive category.

An additional seven field locations taken on forest land initially classified as productive forest land proved to be in the nonproductive category when the current study criteria were used. Also, five of the nine field locations taken on nonproductive forest land and nonforest land and classified by the original timber inventory as productive forest land were also, following field examination, judged nonproductive by the current study criteria.

The productive land lost by reclassification of field samples was not, however, as great as the preceding discussion might suggest. This was because much of this reclassified land had already been excluded for other reasons.

The classification of the field samples by use of study criteria is shown in table 6. Area estimates by classes of land and multiple use land management zones following study procedures are shown in table 7.

Table 7 shows these new estimates of productive forest land area by multiple use management zone, excluding the patches described above, as well as the area excluded because of limited productivity. Of significance also in table 7 is the area in travel and water influence zones. Forest managers currently believe that management requirements will impose some limitation on timber yields in these zones.

Another significant factor in the management of the timber resource of the East Klamath is that some of the area is only potentially usable because of land instability, problems of access, or silvicultural problems. Table 8 shows the area suitable for timber use outside the crest zone available now and potentially available with full yields and modified yields expected.

SINGLE SAMPLING PROCEDURE

In the Pacific Northwest Region (Region 6) a single field sample was used to estimate area

Table 6. — Photo and field classification of field locations used in final area estimates (samples falling on isolated patches excluded), East Working Circle, Klamath National Forest

Photo land class	Sample stratum	Field classification			Total
		Productive forest	Nonproductive forest	Nonforest	
		Number of Locations			
Productive forest	1	16	--	--	16
	2	53	2	--	55
	3	31	--	--	31
	4	23	--	--	23
	5	27	1	--	28
	6	13	--	--	13
	7	13	1	--	14
	8	2	--	--	2
Subtotal	--	178	4	--	182
Unproductive forest	--	1	36	--	37
Nonforest	--	--	2	12	14
Total	--	179	42	12	233

Table 7. — Final estimate of area in acres by class of land and multiple use land management zone, East Working Circle, Klamath National Forest

Multiple use zone	Area by class of land				Total
	Productive suitable	Productive unsuitable[1]	Unproductive	Nonforest	
	Acres				
Crest	2,257	1,765	2,114	1,151	7,287
General forest	357,747	35,712	93,722	29,530	516,711
Travel influence	4,754	1,776	2,515	671	9,716
Water influence	9,778	2,828	3,341	1,438	17,385
Total	374,536	42,081	101,692	32,790	551,099

[1] *Acres of productive forest land in small isolated patches (as small as 1 acre) in delineated areas of rocky noncommercial or nonforest land.*

Table 8. — Area in acres of productive forest land suitable for timber use at full yields and with modified yields by availability class, East Working Circle, Klamath National Forest

Availability class	Full yields expected	Modified yields expected	Total
		Acres	
Available now	335,190	13,826	349,016
Potentially available:			
Stable land with timber growing and access problems	12,719	--	12,719
Unstable, potentially usable land, no other problems	8,715	706	9,421
Unstable land and timber growing and access problems	1,123	--	1,123
Total	357,747	14,532	372,279

and volume. Field samples were mechanically spaced 1.7 miles apart. In the inventory of the Gifford Pinchot Working Circle in 1960, three subplots were taken at each sample location. In the 1969 inventory, the locations established in 1960 were revisited and a standard 10-point plot was established.

In the 1960 inventory, the total area of the working circle was sampled. By contrast, in the 1969 inventory, the obviously noncommercial forest and nonforest land were mapped. Also, a recent soil map and an updated multiple use map were used to further classify locations so that the area of "apparent commercial forest land" could be further stratified.

Before the 1960 and 1969 inventories could be compared, it was necessary to adjust the 1960 estimates. After 1960, a new estimate of area in the Forest was made, recomputing area township by township and section by section where necessary. A new area weight was computed for each location and subplot to correspond with the corrected total area of the Working Circle. Following are the earlier and the current corrected area estimates for the Working Circle by broad land class:

Land class	Earlier estimate	Current corrected estimate
Commercial	1,029,477	1,041,252
Noncommercial	74,553	75,408
Nonforest	38,519	38,960
Total	1,142,549	1,155,620

1969 Inventory

In 1969, the total area in the Working Circle was 1,161,420 acres. The difference between this and the corrected 1960 estimate shown above was due to land exchange and sampling error.

Of the 1,161,420 acres, 135,030 acres were mapped as obviously noncommercial or nonforest. The remaining 1,026,390 acres in the Gifford Pinchot Working Circle plus the Snoqualmie Working Circle of 79,499 acres were field sampled in this inventory utilizing 580 field locations. The area weight of each field sample was 1,906.7052 acres.

$$\frac{1,105,889}{580} = 1,906.7052$$

As a result of field classification and measurement, nine of the locations on the Gifford Pinchot Working Circle were classed as noncommercial. The area associated with these was taken out of the "apparent commercial forest land class" and combined with the "obvious noncommercial" to arrive at total noncommercial. This resulted in area estimates by broad land class as follows:

Land class	Acres
Apparently commercial	1,009,230
Noncommercial	106,280
Nonforest	45,910
Total	1,161,420

Because the sample was so small, it was not possible to further stratify the "apparent commercial forest" by land type and use on a sample basis. This was done by using soil-hydrology maps and multiple use maps with stand or type maps. The samples were used only to identify the categories of land in which to make the correction for field location classification. To illustrate, four of the field locations reclassified from commercial to noncommercial in the field were on forest land mapped as marginal for timber use. The correction for area associated with these four locations was therefore carried into this category.

Area estimates were made utilizing maps. One set of maps showed forest land considered marginal for timber use because of problems of access and timber growing problems. Another set of maps showed land in management units as follows: (1) under study to determine proper land use (deferred); (2) unavailable for timber use; and (3) available for timber use under modified management with partial yields expected.

The results of the 1969 inventory summarized, and using study criteria, are as follows:

Land class	Area in acres	
Category A (commercial):		
Full yields expected	649,064	
Modified yields expected	141,611	
Total — Category A		790,675
Category B (marginal):		130,952
Total — *Timber Growing Base*		921,627
Category C (noncommercial):		
Unproductive forest land	106,280	
Unavailable productive forest land:		
Experimental forest	9,899	
Developed camps & administrative sites	4,853	
Devoted to other uses	53,540	
Total — Category C		174,572
Category D (deferred):		19,311
NONFOREST LAND		45,910
TOTAL ALL LAND		1,161,420

Details on other units

REGION 1 — LOLO UNIT

The Ninemile and Superior Ranger Districts of the Lolo National Forest were used as a study area because of the availability of soils data from a recent soil inventory. This area of 835,133 acres lying west of Missoula and extending to the Idaho boundary is quite steep and rugged; however, the land is sufficiently stable to withstand the strain of timber use. Use of the area by people has increased greatly in recent years. As a result of public pressure to create more recreation capacity, an especially scenic area of 58,953 acres is now under study to determine the most appropriate use. This is the area shown in the "deferred" category in table 2.

Another factor affecting use is the large herds of deer and elk in the area. The large fires that occurred in the area 50 to 60 years ago destroyed forest and created large brush field desirable for big game. Many of these burned-over areas restocked with timber; however, sizable areas still support brush and browse and only sparse timber cover.

Because the area has proved to be desirable big game habitat and has attracted so much attention as a hunting area, big game management must be given appropriate attention. This must be done through timber harvesting and management of forested areas to improve habitat. For areas critical to the maintenance of game herds, it often means maintaining brush and browse cover.

Inventory Problems

In the process of relating timber to both the forest land and forest land use, important data problems were noted. While the study area generally is made up of highly productive timber land (see table 9), as is typical of mountainous country, there are areas of rock talus, exposed bedrock, or bedrock with insufficient soil cover to be considered usable for timber growing. Such areas often support enough timber cover to be called forest land and in the absence of soils data may be included in the estimate of timber growing area. On the study portion of the Lolo National Forest it was discovered that 14,002 acres of unusable rock land had previously been included in the timber growing base.

On the Lolo area it is also significant that because of repeated harsh burns and soil loss following these fires, some areas can no longer be considered timber growing land. In the past, timber inventory has taken the presence of tree stumps and snags as evidence of forest land. In the absence of ecological data they could not do otherwise. In connection with this study, the Forest staff, using ecological criteria, identified 9,433 acres that had been misclassified as productive forest land.

Two other problems became apparent in analyzing the situation; however, data were lacking to quantify them. One problem involved areas that supported stands of stagnated saplings and small pole-size trees that were not likely to ever develop into utilizable timber. It would be desirable if such stands could be identified and treated as a special category in forest land management planning.

The second problem also involves ecology. Apparently, there are areas of peculiar ecology that present difficult timber regeneration problems. It is possible that these could be identified by using present ecological knowledge, but funds have been too limited to permit it.

Table 9. — Timber growing base area in the Lolo study unit by broad soil quality classes as estimated from soil type map

Soil quality class	Timber site range[1]	Acres
Very good	65+	448,729
Good	50-65	70,770
Fair	40-50	81,184
Poor	<40	28,452
Total		629,135

[1] *Tree height at age 50, in feet.*

Summary of the Lolo Unit

Following is a summary of the area of the Lolo study unit by broad land management categories:

Land class	Area in acres	
Category A (commercial):		
Full yields expected	484,448	
Modified yields expected	116,235	
Total — Category A		600,683
Category B (marginal):		28,452
Total - *Timber Growing Base*		629,135
Category C (noncommercial):		
Unproductive forest land	36,535	
Unsuitable forest land:		
Rock land & other unusable land	23,435	
Unavailable productive forest land:		
Crest zone	25,070	
Use conflicts	7,598	
Total — Category C		92,638
Category D (deferred):		58,953
NONFOREST LAND		54,407
TOTAL ALL LAND		835,133

REGION 2 — ARAPAHO NATIONAL FOREST

The Arapaho National Forest is an extremely rugged mountain area with numerous peaks above 11,000 feet. The forest cover is broken by extensive rocky areas especially at the higher elevation and by areas of sagebrush and other nonforest vegetation at the lower elevation.

Most of the timber on the Forest occurs between 7,000 and 11,000 feet where the growing season is short. Generally speaking, timber growing capacity of the land is low, averaging slightly over 40 cubic feet per acre of productive forest land per year. There are some good timber producing sites capable of producing in excess of 80 cubic feet of wood per acre per year, but these are limited.

The Forest is located at the back door of a city of a million people (Denver, Colorado). This combined with the unusual rugged mountain scenery and recreation opportunities has created a strong demand for nontimber uses on the Forest.

The timber inventory previous to this study was made in 1958 when forest use demands were less clear than they are today. Recreation and recreation-related developments since 1958 have taken a significant amount of area out of timber use. As shown in table 2, 127,563 acres of productive timber land can no longer be considered available for timber growing. This does not mean that no timber will be cut from this land. Trees removed in the process of perpetuating the environment will be utilized wherever possible. However, the land itself will not be managed for a timber crop.

In addition to the 127,563 acres not available for timber use, there are about 34,000 acres which will be used on a modified management basis but from which full yields cannot be expected if other forest land use objectives are met.

Land stability is not a major problem on the Arapaho National Forest. Patches of unstable land comprising only a little over 2,000 acres are too unstable to stand the strain of timber use (table 2). A substantially larger area is considered only potentially usable, pending improvement in timber harvesting technology:

Stability class	Acres of timber growing land
Unstable, potentially usable (Including 3,816 acres on slopes over 60 percent)	45,654
Stable land	326,455
Unclassified, assumed to be stable	27,462
Total	399,571

A major factor limiting timber use at present is steepness of slopes. Harvesting technology used in the area is limited to slopes under 40 percent. As the table relation below shows, a significant amount of the productive forest is on slopes steeper than 40 percent.

Slope class (Percent)	Acres of commercial forest land
0-40	343,144
41-60	52,611
Over 60	3,816
Total	399,571

Information Deficiencies

As on the Lolo, problems were also noted on the Arapaho that could not be adequately described by using the data available. The most significant of these problems was the lack of information to identify areas supporting stagnated stands not likely to develop to utilizable size and, therefore, of marginal value for timber use.

In addition, there is need for ecological data that will permit identification of timber growing problem areas.

Summary of the Arapaho National Forest

As previously indicated, forest land use, land stability, and steepness of slope are significant factors affecting timber production on the Forest. Following is an area summary for the Forest by broad land management classes:

Land class	Area in acres	
Category A (commercial):		
Full yields expected	308,026	
Modified yields expected	28,650	
Total — Category A		336,676
Category B (marginal):		
Potentially usable stable land:		
Full yields expected	11,790	
Modified yields expected	5,451	
Potentially usable unstable and steep land:		
Unstable 40-60% slopes	41,838	
Slopes over 60%	3,816	
Total — Category B		62,895
Total — *Timber Growing Base*		399,571
Category C (noncommercial):		
Unproductive forest land:		
Photo	45,418	
Field adjustment	67,185	
Productive unsuitable forest land:		
Unstable	2,193	
Isolated patches	9,908	
Productive unavailable forest land:		
Crest zone	21,889	
Travel-water influence	53,324	
Other use conflicts	52,350	
Total — Category C		252,267
Category D (deferred):		64,885
NONFOREST LAND		231,114
TOTAL ALL LAND		947,837

REGION 3 — COCONINO NATIONAL FOREST

The Coconino National Forest in northern Arizona was selected by the Southwestern Forest Service Region 3 as a study area. This forest of 1,774,710 acres on the Arizona Plateau is largely a ponderosa pine forest and is for the most part stable. Some fir and spruce occur, primarily in the San Francisco Peaks area of the Forest. A significant amount of the area is forested but the soil is not considered suitable for timber growing. Also, there are limited areas not considered operable at this time with the technology available.

Generally speaking, the Coconino National Forest is low in productivity. While there is some forest land (about 14 percent) capable of producing in excess of 50 cubic feet of wood per acre per year, the remainder has a yield

capability of from 20 to 50 cubic feet of wood per acre per year. A major problem in relation to productivity is at the lower elevational fringe of the forested zone. Much of this land simply will not support enough trees to meet the productivity level required for commercial forest.

Another major factor affecting timber inventory on this unit is the changing land use. Pressure on the Forest by people is increasing rapidly and as a result, an ever-increasing amount of forest land is being devoted to nontimber uses.

Summary of the Coconino National Forest

Normal timber inventory procedure. — The Coconino National Forest was studied at the same time it was being reinventoried for timber. As a consequence it is possible to directly contrast the study criteria and the land classification criteria applied in the reinventory.

The primary aerial photo point sample taken on the Forest involved 8,300 samples. Following is the estimate of area by broad land class based on those samples.

Land class	Acres
Productive forest land	902,522
Unproductive forest land	516,390
Nonforest land	355,798
Total	1,774,710

A subsample of 271 photo point samples was drawn for field checking of land class and measurement. The results of the field classification were then used to correct the primary sample estimates. As a result of the field check, 24 samples classed as productive forest land on the aerial photos changed to nonproductive. In other words, 24 of the field samples did not meet the productivity criteria of 20 cubic feet of wood per acre per year because of low site. Following are the corrected estimates of area by broad land class:

Land class	Acres
Productive forest land	854,355
Nonproductive forest land	564,431
Nonforest land	355,924
Total	1,774,710

Study criteria applied. — Using the additional data collected on stocking capability, it was possible to more realistically assess land productivity. In addition, it was possible to use available soil data for identification of land that, while supporting some timber, was from a soil point of view alone, not to be considered timber growing land. Also, it was possible to use available vegetation type information for identification of areas where the soil was adequate, but because of moisture limitations was not suitable to produce commercial tree species.

Productive forest land in the crest zone was considered unsuited for timber use. Also considered unavailable for timber growing was productive forest land in the special multiple use zone, including such things as experimental areas and designated natural areas and land in management units managed primarily for nontimber uses. Following are the results of applying the study criteria:

Land class	Area in acres	
Category A (commercial):		
Full yields expected	436,702	
Modified yields expected	41,267	
Total — Category A		477,969
Category B (marginal):		
Currently inoperable	67,804	
Fringe and low site areas	22,888	
Total — Category B		90,692
Total — *Timber Growing Base*		568,661

Land class		Area in acres
Category C (noncommercial):		
Unproductive forest land	682,557	
Productive unsuitable forest land:		
Noncommercial forest soils	108,285	
Isolated patches	287	
Productive unavailable forest land:		
Crest zone	210	
Special zone	15,974	
Use conflicts	20,605	
Total — Category C		827,918
Category D (deferred):		22,207
NONFOREST LAND		355,924
TOTAL ALL LAND		1,774,710

REGION 4 — BOISE UNIT

The Cascade and Garden Valley Ranger Districts of the Boise National Forest were used as the Intermountain Region's contribution to this effort. These two Districts are in the Idaho Batholith, a land formation well known for its unstable and highly erodible character. Much of the area is quite rugged and steep in addition to being highly erodible. The management of the land is further complicated by the fact that the area is a very important source of water. Also, the major streams support anadromous fish. The South Fork of the Salmon River, for example, is an important salmon spawning area.

Thus, these two Ranger Districts contain major areas which are extremely sensitive, but they also include some of the most productive timber land in the Intermountain Region of the Forest Service. Twenty percent of the commercial forest land in the study area has the capacity to produce in excess of 100 cubic feet of wood per acre per year. The landforming processes that shaped the area involved glaciation and left a lot of area of low productivity. Inventory procedures of the past have not adequately reflected this. As was indicated by data in table 2, over 23,000 acres previously classed as productive forest land lacked the required productive capacity when stocking capability was considered.

Demands for timber land for nontimber uses have also increased significantly in recent years. The rugged mountain scenery, the fishing streams and lakes, as well as the large and small game animals and birds attract large numbers of people. Around some of the lakes and along the more popular fishing streams, significant recreation complexes have already been developed and others are planned. In addition, the study area joins an established primitive area into which visitors to local dude ranches and camps make wilderness excursions.

Summary of the Boise Unit

Following is a summary of the area in the Boise Unit by broad land management categories:

Land class		Area in acres
Category A (commercial):		
Full yields expected	151,720	
Modified yields expected	47,045	
Total — Category A		198,765

Land class		Area in acres
Category B (marginal):		
Full yields expected	27,692	
Modified yields expected	46,831	
Total — Category B		74,523
Total — *Timber Growing Base*		273,288
Category C (noncommercial):		
Unproductive forest land	54,350	
Unsuitable forest land:		
Unstable land	25,579	
Isolated patches	11,233	
Unavailable forest land:		
Crest zone	27,127	
Use conflicts	16,180	
Total — Category C		134,469
Category D (deferred):		5,566
NONFOREST LAND		43,542
TOTAL ALL LAND		456,865

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Headquarters for the Intermountain Forest and Range Experiment Station are in Ogden, Utah. Field Research Work Units are maintained in:

Boise, Idaho
Bozeman, Montana (in cooperation with Montana State University)
Logan, Utah (in cooperation with Utah State University)
Missoula, Montana (in cooperation with University of Montana)
Moscow, Idaho (in cooperation with the University of Idaho)
Provo, Utah (in cooperation with Brigham Young University)